AN INDEX OF BIOTIC INTEGRITY FOR WADEABLE STREAMS IN THE APALACHICOLA AND ATLANTIC SLOPE DRAINAGE BASINS IN THE PIEDMONT ECOREGION OF GEORGIA

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REFERENCE: Proceedings of the 2001 Georgia Water Resources Conference, held March 26-27, 2001, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, the University of Georgia, Athens, Georgia.

Abstract. An Index of Biotic Integrity (IBI) was developed to assess the condition of wadeable streams in the Piedmont ecoregion of Georgia based on the fish communities present. Data collected from 181 sample sites throughout six major drainage basins were used to develop Maximum Species Richness plots and scoring criteria for 13 IBI metrics. Potential Piedmont reference sites were identified and will undergo long-term trend monitoring. Samples collected in 1998 and 1999 resulted in the listing of 12 stream segments to the Environmental Protection Division's list of impaired waters and the de-listing of 40 other stream segments.

INTRODUCTION

The original IBI was developed by Karr (1981) to evaluate environmental degradation in wadeable streams in the midwestern United States. It consisted of 12 metrics that assessed three facets of the fish community: species richness and composition, trophic composition and dynamics, and fish abundance and health. Due to regional differences in the fish fauna between the midwestern and southeastern portions of the United States, the original IBI developed by Karr (1981) required modification for use in the Piedmont ecoregion of Georgia.

The Fisheries Section of the Wildlife Resources Division (WRD), a branch of the Georgia Department of Natural Resources, has developed an IBI for wadeable streams in the Chattahoochee, Flint, Ocmulgee, Oconee, Ogeechee, and Savannah drainage basins throughout the Piedmont ecoregion of Georgia An additional year of sampling and the ability to effectively sample larger and more diverse streams has lead to several changes in the metrics and scoring criteria reported earlier (Shaner 1999). The protocols outlined in this paper are now required as a condition for obtaining scientific collection permits of all individuals and firms sampling fish communities for obtaining municipal or corporate discharge permits or conducting watershed assessments throughout the Piedmont ecoregion.

SAMPLING METHODS

Sample reaches consisted of a single electrofishing pass at 35 times the mean stream width (MSW) without block nets. Sampling methods for small streams (generally less than eight meters MSW) using one or two backpack electrofishing (BPEF) units were outlined in Shaner (1999). Larger streams (generally greater than eight meters MSW) were sampled with a barge electrofishing unit, which allows for two to three electrofishing probes to be operated simultaneously, depending on the width and depth of the sample reach. Sample processing procedures and other sampling protocols are the same as when using BPEF units.

SAMPLE SITES

Fish community samples were collected from April through October in 1998 and 1999. A total of 181 sites were sampled in 30 counties throughout the Piedmont ecoregion (Fig. 1). Sites ranged in size from one square mile drainage basin area to over 260 square miles drainage basin area. Of these, 138 sites were related to stream segments previously listed on the Environmental Protection Division (EPD) 303(d) list as being impaired based on the results of a previous biomonitoring study (Schlieger 2001). Six of the sites were sampled for a Natural Resources and Conservation Service (NRCS) study on agricultural Best Management Practices and four sites were sampled in conjunction with a US Environmental Protection Agency study in the Savannah River drainage basin. One site was sampled

Table 1. IBI metrics used by the Georgia Department of Natural Resources to assess the biotic integrity of fish communities in wadeable streams in the Piedmont ecoregion of Georgia.

Metrics	Drainage Basin Area	Scoring Criteria 5	3	1
Species Richness and Composition				
1. Total number of native fish species	All			
2. Total number of benthic invertivore species	All			
3. Total number of native sunfish species	All			
4. Total number of native cyprinid species	All	Scoring for metrics 1 – 6 from MSR plots		
5. Total number of native sucker species	All			
6a. Total number of intolerant species	≥20 sq. mi.			
6b. Total number of sensitive species	< 20 sq. mi.			
7. Evenness	All	≥ 70	70 - 58	≤ 58
Trophic Composition and Dynamics				
8a. Proportion of individuals as omnivores	< 20 sq. mi.	< 14	≥ 14 - 28	≥ 28
8b. Proportion of individuals as sunfish species	≥ 20 sq. mi.	< 26	≥ 26 - 46	≥ 46
9. Proportion of individuals as insectivorous cyprinids	All in AS	> 54	≤ 54 - 33	≤ 33
	All in ACF	> 44	≤ 44 - 22	≤ 22
10a. Proportion of individuals as top carnivores	≥ 10 sq. mi.	> 3.5	≤ 3.5 – 2.0	≤ 2.0
10b. Proportion of individuals as pioneer species	<10 sq. mi. in AS	< 42	≥ 42 - 69	≥ 69
	<10 sq. mi. in ACF	< 29	≥ 29 - 58	≥ 58
Fish Abundance and Condition				
11a. Number of individuals collected per 200 meters	≥ 10 sq. mi.	> 700	≤ 700 – 350	≤ 350
11b. Number of individuals collected per 200 meters	< 10 sq. mi.	Scored from MSR plots		
12a. Proportion of individuals as simple lithophilic spawners	≥ 10 sq. mi.	> 54	≤ 54 - 30	≤ 30
12b. Number of native simple lithophilic spawning species	< 10 sq. mi.	Scored from MSR plots		
13. Proportion of individuals with external anomalies	All	> 1.2 – subtract 4 from total IBI score		

Table 2. Total IBI scores, integrity classes, and their attributes (modified from Karr 1981 and Schleiger 2001).

Score	Integrity Class	Attributes
60-52	Excellent	Comparable to the best regional reference conditions; all regionally expected species for the habitat and stream size, including the most intolerant species, are present with a full array of size classes; sucker, minnow, and benthic invertivore species abundant; significant proportion of the sample composed of simple lithophilic species; number of individuals abundant, representing a balanced trophic structure; evenness values greater than 70.
50-44	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; good number of individuals, with several species of suckers, minnows, and benthic invertivores present; trophic structure shows some signs of stress.
42-34	Fair	Species richness declines as some expected species are absent; sucker, minnow, and benthic invertivores in low abundance; trophic structure skewed toward generalist species as the frequency of omnivores and other tolerant species increases; abundance of simple lithophilic species decreases; increase in the frequency of pioneer species.
32-26	Poor	Sample dominated by omnivore, tolerant, and pioneer species; some samples may be dominated by sunfish; sensitive species absent; sucker, minnow, and benthic invertivore species in low abundance or absent; growth rates and condition factors commonly depressed and diseased fish are often present; number of individuals in low abundance; evenness values less than 60.
24-8	Very Poor	Few fish present, mostly tolerant and pioneer species; fish with disease, eroded fins, lesions, and tumors common.
	No Fish	No fish collected with repeated sampling.

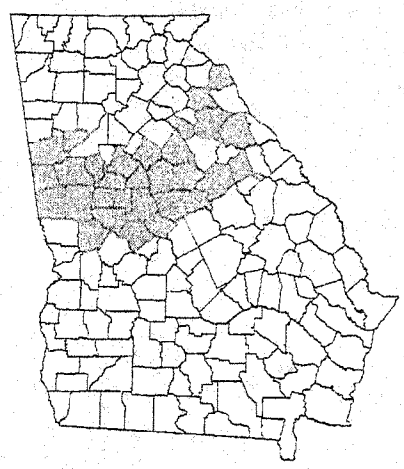

Figure 1. Counties in the Piedmont ecoregion of Georgia where IBI samples were collected in 1998 and 1999.

for both the EPD 303 (d) list and the NRCS study. The remaining 34 sites were sampled as potential reference sites for establishing scoring criteria and expectations of minimal disturbance throughout the Piedmont ecoregion. Potential reference sites were selected based on previous fish community data (Schleiger 2001), recommendations of fisheries and ecological professionals throughout Georgia, and land use, road density, and urban/suburban development within the surrounding watershed area.

IBI DEVELOPMENT AND METRICS

For the purpose of developing biomonitoring protocols and IBI scoring criteria, the six major drainage basins sampled in the Piedmont ecoregion were aligned into two groups based on similarities in species richness and composition. The Apalachicola Drainage Basin (ACF) includes the Chattahoochee and Flint basins, while the Atlantic Slope Drainage Basins (AS) includes the Ocmulgee, Oconee, Ogeechee, and Savannah basins.

Streams with larger drainage basin areas naturally have increased species richness over streams with smaller drainage basin areas. To incorporate this trend in metric scoring, Maximum Species Richness (MSR) plots were developed for each species richness metric of the IBI. MSR plots were derived by plotting the number of species collected for a given metric against the log-transformed values of the drainage basin area. A line delineating the 95th percentile was drawn by eye and the area under the line was trisected. Where data allowed, a line delineating the 5th percentile was also drawn, and the area between the two lines was trisected. Data points falling into the top third of the trisection scored a 5, those falling in the middle trisection scored a 3, and those falling in the bottom trisection scored a 1. Differences in species richness and diversity required that separate MSR plots be developed for both the AS and ACF groups.

Species composition is less reliant on stream size than species richness. Scoring for species composition metrics was determined by plotting the data for a given composition metric against the log transformed value of the drainage basin area. Horizontal lines delineating the 95th and the 5th percentiles were drawn by eye and the area between the lines was trisected.

Pollution tolerance rankings and reproductive and trohpic guild designations were facilitated by regional ichthyological texts, rankings employed by other agencies conducting fish biomonitoring in the southeastern US (O'Neil and Shepard 1998; North Carolina Department of Environment, Health and Natural Resources 1997; Tennessee Valley Authority 1997), and suggestions from ichthyologists familiar with Georgia's fish fauna. MSR plots, scoring criteria for the IBI metrics, and a list of the fish species found in the AS and ACF drainage basins within the Piedmont ecoregion along with their pollution tolerance rankings and reproductive and trophic guild assignments are available from the Georgia WRD.

Metrics 1-7 evaluate species richness and species composition at a site (Table 1). These metrics assess the health of the major taxonomic groups and habitat guilds of fishes, the availability of spawning habitat and food resources, and the diversity of the fish community. Metrics 8 – 10 measure the trophic composition and dynamics at a site. These metrics evaluate the quality of the energy base and the flow of energy through a stream community and assess the availability of appropriate habitats to support a trophically diverse biotic community. Metrics 11 – 13 evaluate attributes of the fish community, including population density, recruitment potential, and individual fish health. Natural variations in species composition and diversity due to differences in drainage basin size and origin required modifications to several of the composition metrics to increase their utility as measures of environmental degradation in the Piedmont ecoregion.

Based upon the combined scores of the 13 IBI metrics, sample reaches were assigned to one of five integrity classes, ranging from excellent to very poor (Table 2). A sixth class, no fish, was added for sites where no fish were collected with repeated sampling.

RESULTS AND DISCUSSION

Individual IBI scores ranged from 12 to 56 for sites sampled during the 1998 and 1999 sample season. Of the 138 sites sampled that were directly related to sites already on the EPD list of impaired waters, 7.2% (N = 10) scored good, 32.6% (N = 45) scored fair, 26.8% (N = 37) scored poor, and 33.3% (N = 45) scored very poor. Five sites scored fair and one scored poor in the preliminary sampling for the NRCS study and one site scored good and 3 scored fair in the EPA study on the Savannah River drainage basin. Sample results by integrity classes for each basin group are summarized in Table 3.

More than a quarter of the sites (N = 9) sampled as potential reference sites scored excellent. These nine sites varied in drainage basin area from less than 5 square miles to greater than 260 square miles. Approximately five percent of the sites sampled in each basin group scored excellent. Five of the sites that scored excellent were in the AS drainages (two in the Ocmulgee, two in the Oconee, and one in the Ogeechee) and four were in the ACF drainages (two each in the Chattahoochee and Flint). Of the remaining potential reference sites sampled, 13 scored good, 10 scored fair, and two scored poor.

Based on their IBI scores, nearly half the sites sampled in 1998 and 1999 scored poor or very poor. Less than 20% of the sites scored better than fair. The preponderance of sites categorized in the lower integrity classes was an expected result of the 1998 and 1999 samples, since over 75% of the sites were directly related to the EPD list of impaired waters. It was not intended for these samples to represent the overall quality of streams throughout the Piedmont ecoregion of Georgia. However, the samples collected from the potential reference sites provided a reliable estimate of least impaired conditions throughout the ecoregion, allowing for the development of IBI metrics and scoring criteria.

EPD considered all sample sites that scored poor or very poor to be impaired waters and included them on the 303(d) list for TMDL development. Sites that scored fair or better were considered to be supporting their designated uses (primarily drinking, fishing, or recreation). Any stream segment listed on the 1998-1999 303(d) list that scored fair or better was removed from the 2000-2001 list. Based on the 1998-1999 sample results, 40 stream segments were removed from the 303(d) list. Twelve previously unlisted stream segments were added to the 2000-2001 list based on impaired fish communities.

Table 3. Results of the 1998 and 1999 fish biomonitoring samples by basin group.

	Integrity Class				
	Excellent	Good	Fair	Poor	Very Poor
AS Sites	5	15	38	27	21
ACF Sites	4	9	24	14	24
Total Sites	9	24	62	41	45

Development of a biomonitoring program throughout Georgia continues. In 2000, 145 samples were collected in the AS and ACF drainages in the Southeastern Plains (SEP) ecoregion. A standard operating procedures manual for conducting biomonitoring on fish communities in the SEP ecoregion should be available by spring 2001. Sampling for 2001 will occur in the Coosa and Tallapoosa drainage basins in the Ridge and Valley and Piedmont ecoregions. Long-term trend monitoring of potential reference sites continues in the Piedmont and other ecoregions throughout Georgia.

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